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# BIOLOGICAL EVALUATION OF TREE MORTALITY AT FORT BIDWELL INDIAN RESERVATION

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## ABSTRACT

Mortality of white fir and ponderosa pine was scattered throughout the predominantly white fir stands at Fort Bidwell Indian Reservation in northeastern California. Contributing causes included competition and stress from overstocking, fir engraver, mountain pine beetle, pine engraver, annosus root disease, and white fir dwarf mistletoe. The implications of these pests for forest management are discussed, and methods of reducing their damage are presented.

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## INTRODUCTION

In the fall of 1981, Eric Natti, Bureau of Indian Affairs (BIA) forester in Sacramento, requested that FPM evaluate the causes of tree mortality at Fort Bidwell Indian Reservation in northeastern California. The Tribal Council had begun a long-term forest improvement program, and the BIA wanted to determine how pest conditions on the forest might affect the Tribe's plans. Because of foul weather, we were unable to visit the site until late spring 1982. On June 2nd, Vogler and Dale drove with Natti to Fort Bidwell. We were joined there by Richard Bellon, Tribal Manager, and Irvin Toler, a consulting forester hired by the Council to implement the forest plan.

## OBSERVATIONS

The 1600-acre timbered portion of the Reservation is predominantly white fir with scattered ponderosa pine and incense-cedar. Evidence suggests that ponderosa pine was once more common than it is today, but selective removal of much of the pine and larger white fir has allowed the fir to invade and dominate the formerly mixed conifer stands. Much of the forest appears to be overstocked, and growth rates began to decline about 20 years ago.

Scattered, light mortality of ponderosa pine and white fir was evident throughout the forest. Galleries of the fir engraver, Scolytus ventralis, were found under the bark of the dead white fir, and old spike tops and newly faded tops probably were caused by this insect. Mortality was cumulative over several years, and consisted of individual firs and aggregates of up to seven trees. Dead and dying firs were particularly common along the northern boundary of the forest, although many of the 60 to 80 dead firs in this area may have been on private land. Death of the firs had resulted in release of pines in some locations.

The mountain pine beetle, Dendroctonus ponderosae, was killing pines in the SE-1/4 of section 13 and the SW-1/4 of section 18. This mortality occurred in groups of 3-4 trees, and occasionally in groups of 5-6 trees. Pines up to 20 inches d.b.h. were involved, but the average diameter was approximately 12 inches. Although the average stocking per acre may not be excessive in this area, the mortality was frequently located in densely stocked patches. It is this immediate competitive environment that is important, not the sometimes misleading figure of basal area per acre. Fading pines were also seen along the northern boundary of the forest. No doubt the pine engraver, Ips pini, is involved in the pine mortality in both areas.

In addition to overstocking, the 1976-77 drought and below-normal rainfall in 1979 and 1981 may have predisposed some firs and pines to insect attack.

Annosus root disease - caused by the fungus Fomes annosus - was affecting both fir and pine. Conks (fruiting bodies) of the fungus were found inside most of the large white fir stumps examined; in the upper Soldier Creek unit we found several infection centers containing 2-5 stumps each. Several annosus-infected pine stumps were found in both the upper Soldier and Venning Creek units. In one pine infection center, three incense-cedar were dead and one was dying from F. annosus.

Dwarf mistletoe (Arceuthobium abietinum f. sp. concoloris) was infecting white fir to varying degrees throughout the forest. Infection was most severe in the higher-elevation, pure fir stands; in one cut-over site in the extreme northwest portion of the forest, infection in the residual pole- and small sawtimber-size firs was particularly damaging. Branch flagging caused by a canker fungus, Cytospora abietis, was prominent on many of the mistletoe-infected firs. Western dwarf mistletoe (A. campylopodum) appeared to be absent from the pine.

We noted two minor disease conditions: a rust caused by Gymnosporangium libocedri was seen on several incense-cedar in the upper Venning Creek unit, and one white fir in the upper Soldier Creek unit was infected by Virgella robusta, cause of a needle cast of true firs. Neither disease has any management significance at present.

## PEST BIOLOGY

Insects, fungi, and parasitic plants often interact to reduce the health and vigor of forest stands. Although discussed separately here, the following pests all contributed to the growth loss and mortality seen in the Ft. Bidwell forest.

### FIR ENGRAVER

Scolytus ventralis attacks most true firs in western North America. Attacks can result in mortality, top-kill, or patch kill along the bole in firs ranging from large saplings to old-growth. Mortality and top-kill frequently are associated with stress induced by overstocking, drought, root disease, soil compaction, excessive and sudden exposure, heavy dwarf mistletoe infections, and other factors limiting tree health and vigor. Because of the sporadic occurrence of widespread, severe mortality and top-kill, and the prevalence of healthy broods in living trees (patch attacks), direct control measures are generally impractical. A healthy, vigorously growing stand is the best means of minimizing fir engraver damage.

Adults fly and attack trees or green fir slash between June and September; larvae, pupae, and adults overwinter under the bark of infested trees. The life cycle takes one year, rarely two. Pitch tubes are not formed as with pine bark beetles, but attacks are often characterized by boring dust in bark crevices along the trunk and pitch streamers on the mid- and upper-bole. Trees successfully attacked early in the summer may exhibit fading of the foliage by early fall, but those attacked later in the year will not begin to fade until the following spring or summer. The beetles may have emerged by the time the tree fades.

Several other species of Scolytus, along with Pseudohylesinus, may be associated with the fir engraver. These contribute to the damage, as does the roundheaded fir borer, Tetropium abietis, which is also a frequent associate.

### MOUNTAIN PINE BEETLE

The mountain pine beetle, Dendroctonus ponderosae, was the most common bark beetle at the sites examined. This insect produces one generation per year. Adults attack trees and lay eggs from late June through August. They bore 2-4 ft. long vertical egg galleries in the phloem/cambium region from breast height to mid-crown, and lay eggs in niches along the sides of the gallery. A J-shaped hook is common at the lower 1-2 inches of the gallery. The larvae feed in mines perpendicular to the main gallery, and construct small pupal cells at the end of these mines, where they pupate and transform into adults.

Beetle damage is recognized by pitch tubes along the bole and red boring dust in bark crevices and on the ground. After successful attack, foliage becomes greenish yellow, then reddish brown within a short period. The beetle is often active and devastating in densely-stocked stands of pole-size trees.

PINE ENGRAVER

Ips pini is common throughout western North America and is most frequently found in California in the eastside pine type. It commonly attacks freshly-cut logs, slash, breakage, tops, and limbs of ponderosa, Jeffrey, and lodgepole pines. Attacks on tops and limbs may preceed or occur simultaneously with attacks by Dendroctonus bark beetles. When suitable host material is plentiful, such as slash or drought-stressed pines, large numbers of beetles may develop and attack apparently-healthy pines. Young pines 2-8 inches d.b.h. and the tops of older trees are the host material most at risk. This is particularly true of densely stocked groups of trees. Fortunately, outbreaks are usually of short duration and seldom last more than one season.

Attacking adults may be found under the bark constructing a typical three- or four-branch egg gallery from a central nuptial chamber. These galleries run parallel with the wood grain and assume a Y or H pattern. The galleries are kept clear by the adults and consequently the reddish boring dust piles up near the entrance holes. The dust is particularly visible on horizontal host material such as blowdown. On standing trees it catches on bark flakes, crevices, and spider webs. On the Ft. Bidwell forest, 2-3 generations can be expected per year -- two summer generations following spring emergence of adults, and possibly a third that will overwinter as adults, either under the bark or in forest litter.

Beetle numbers are primarily affected by the abundance of suitable host material. Therefore, management practices should provide the least possible quantity and quality of suitable material. This can be done by utilization or by treating residues in such a way that the inner bark desiccates quickly - lop and scatter, chipping, or burning. Outbreaks in standing trees and top-killing can be minimized by proper disposal of slash and windthrown material, and by maintenance of tree vigor through thinning of dense immature stands.

ANNOSUS ROOT DISEASE

Fomes annosus attacks a wide range of woody plants, decaying the wood and killing the sapwood and cambium. The fungus can spread long distances above ground by air-borne spores; these are produced by conks in decayed stumps, under the bark of dead trees, or under the duff at the root collar. The spores land on freshly-cut stump surfaces or on wounds in living trees, germinate, and colonize the new site.

Once established in a stump or tree, the fungus grows into and through the host roots until it contacts the roots of adjacent trees, where it infects and invades their root systems. In this way, F. annosus spreads from stumps or dead trees into the roots of living trees in an enlarging infection center. The fungus may also spread underground into adjacent fresh stumps or recently-dead trees, but only if they are not already colonized or decayed by other fungi.

F. annosus can remain viable in old infected roots or stumps for as long as 50 years. Infection centers usually continue to enlarge until they reach natural barriers such as openings or groups of non-host plants. Young conifers established within infection centers often die shortly after their roots contact infected roots in the soil.

F. annosus attacks most conifers. It kills pines relatively quickly without causing extensive decay. The fungus spreads through the inner bark and sapwood of the root system, killing these tissues; within 2-6 years it reaches the root crown and girdles the tree. By contrast, true firs are seldom killed directly. The fungus spreads into the heartwood of the larger roots, and then into the lower bole of the host, where it causes a butt rot. Vigor and volume are reduced, but death is usually the result of insect attack or windthrow.

Generally, firs growing within pine disease centers are highly susceptible to annosus infection, while pines adjacent to infected fir stumps usually escape attack. Thus, large fir infection centers can be revegetated by selecting for or planting pines.

## WHITE FIR DWARF MISTLETOE

Arceuthobium abietinum f. sp. concoloris infects white fir and grand fir, but has never been found on red fir. Red fir is infected by a closely-related host form. Pines are not susceptible.

Dwarf mistletoes are flowering plants that require a living host, from which they obtain most of their nutrients and all of their minerals and water. They spread by means of sticky seeds that are forcibly discharged from the plants in the fall and adhere to whatever they contact. If a seed lands on a host needle or twig, it remains there over winter; the following spring it germinates, and the radicle penetrates the host. The parasite develops a root-like endophytic system in the inner bark and outer sapwood, and produces aerial shoots within 2-4 years after initial infection. On true firs, another 3-5 years elapse before seed are produced.

The spread of dwarf mistletoe is limited to the distance travelled by the seed, which from overstory to understory is usually 20 to 60 feet; with the aid of wind, the seed may be carried as far as 100 feet. A rule of thumb is that dwarf mistletoes can spread a horizontal distance equal to the height of the plants in the infected tree. Because of various limits to spread and the long life cycle, the actual spread rate

through an even-aged stand is usually 1 to 2 feet per year. Vertical spread in true fir is limited by the density of the crown; on the average, the parasite moves upward about 3 inches per year.

Unlike western dwarf mistletoe (A. campylopodum), which infects ponderosa and Jeffrey pines, white fir dwarf mistletoe seldom produces large brooms (abnormal proliferations of twigs that appear as clustered masses of foliage). It does, however, cause large swellings in the stems of long-infected firs. These swellings may grow to twice the normal diameter of the stem, and often are extensively decayed and susceptible to breakage.

### CYTOSPORA CANKER OF TRUE FIRS

Cytospora abietis is a canker-causing fungus that occurs on true firs throughout their range in California. It is a weak parasite, and usually attacks trees that have been weakened by disease, drought, fire, insects, or human activity. It is most commonly associated with dwarf mistletoe infection, and sometimes attacks as many as a quarter of the mistletoe-bearing branches, killing many each year. C. abietis occasionally reaches especially damaging proportions in certain years, and may attack trees of any age, killing the tops or all of young trees.

## PEST MANAGEMENT CONSIDERATIONS

Without management, these stands will continue to deteriorate and grow more susceptible to insect attack during a drought or other time of stress. The present forest composition - characterized by overstocked white fir stands dominating pine and mixed conifer sites - is probably the result of an historical lack of management combined with repeated mountain pine beetle attacks that killed most of the pine on many sites, allowing fir to predominate. This condition was documented by Eaton in the North Warner Mountains in 1941, when he found that bark beetle damage was severe enough in some areas to change the ratio of the two species from 50:50 to almost 100 percent fir. Annosus root disease will continue to kill pines in discrete centers, but the disease will have a greater effect on white fir stands that lack a pine component. Annosus root disease, dwarf mistletoe, and fir engraver will, in combination and individually, reduce the numbers and quality of the white fir, and may allow pine to reclaim portions of some sites.

### SANITATION-SALVAGE OF THE WHITE FIR

To claim the white fir volume that is most likely to be lost to decay and fir engraver attack, harvest the firs using the following marking guides.

- Remove severely-infected firs with dwarf mistletoe ratings of 5 or 6 (see Appendix).
- Select against firs near annosus root disease centers.

- Select against firs recently top-killed by fir engravers down to a stem diameter of 6 inches or more. For firs top-killed to a diameter of less than 6 inches, select against them only if other signs of decline exist (including extreme loss of older needles, or yellow-green foliage combined with a heavy cone crop).

- Remove firs with open basal scars or old dwarf mistletoe bole swellings that exhibit advanced decay.

- Remove firs with less than 30 percent live crown because of recent pest activity (including severe dwarf mistletoe or Cytospora infections, and successful fir engraver attacks).

- Clear pitch-streamers on the boles of green firs indicate healing at the sites of aborted fir engraver attacks. Do not select against these firs unless two representative felled firs show that the beetles have been successful in overcoming the host resistance indicated by the streaming.

- For fire-scorched firs, consult Willis Wagener's "Guidelines for estimating the survival of fire-damaged trees in California" (1961).

## OVERSTORY REMOVAL AND THINNING OF WHITE FIR STANDS

Aggressive stand management will lower the threat of fir engraver attack by controlling stocking; reduce the impact of dwarf mistletoe by eliminating the most severely infected trees and stimulating the growth of residuals; and perhaps stimulate pole-size and larger firs to grow sufficient new roots to offset those lost to annosus decay. Where pines are present, selecting against the least-healthy fir will promote a more mixed stand that will inhibit the spread of white fir dwarf mistletoe and Fomes annosus. Specific considerations for managing the latter two diseases follow.

**WHITE FIR DWARF MISTLETOE.** If infected, two-story white fir stands are left untreated, the understory will be showered with mistletoe seeds and its growth will be seriously affected by repeated upper crown infections. Research has shown that pole-size and smaller fir stands will respond well to release and will outgrow the upward spread of the parasite. Use the following guidelines in treating such stands.

- Remove the overstory to release residuals and to prevent continued re-infection from overhead.

- Thin the residual stand for optimum growth. The presence of mistletoe need not be the primary factor in leave tree selection, but rather should be considered after crown

Where direct control is inadequate, silvicultural methods are the only way to reduce the impact of the disease. Promoting mixed stands of pine and fir is beneficial, since the fungus generally does not spread from true fir stumps to pine. Hardwoods, which are immune to the disease, may be used as barriers to spread. Since F. annosus primarily acts as a decay in true firs and kills them much more slowly than it kills pine, stocking control for optimum growth may be the best way to forestall its effects in pure fir stands.

## REDUCING LOGGING INJURY IN YOUNG-GROWTH WHITE FIR STANDS

Overstory removal and thinning of young-growth white fir can severely injure the residual stand, leading to substantial decay and volume loss by the next rotation. These guidelines, if followed during logging activities, should greatly reduce damage to residual trees. They were developed for stands with non-resinous species, and are based on work done by the Pacific Northwest Experiment Station in cooperation with Forest Pest Management and the Silvicultural Development Unit in Redding.

- Restrict the logging season. Do not allow entry during the spring and early summer when the bark is loose.

- Restrict the size and type of logging equipment. Match the logging system to the topography. Use cable systems on slopes steeper than 35 percent. Match machine size to the type and size of material being removed.

- Mark the residual trees. When leave trees rather than cut trees are marked, the operator becomes more aware of which trees are to be protected.

- Lay out skid roads in advance of logging. Skid trails should not be cleared wider than the skidding vehicle. Use straight-line skid trails.

- Leave buffer (bump) trees. When possible, leave cull logs and bump trees along the edges of skid trails. Remove bump trees during the last turn.

- Limit the log length. Relate log length to the spacing of the residual stand. Avoid whole tree logging.

- Log the skid trails first. To keep the skidder from veering into leave trees, cut the stumps in the skid trails as low as possible, no more than 3-4 inches high.

- Use directional felling. Fall trees toward or away from the skid trails to reduce skidder maneuvering. Back the skidder toward the direction of the fall.

- Limb, top, and buck trees prior to skidding.

- Do not thin stands of thin-barked species too heavily. Sunscald can cause considerable damage.

- Gain the contractor's cooperation. Instruct operators in methods of reducing damage. Inform the contractor that damage will not be tolerated and explain why. Communicate the desired results to the contractor and maintain supervision, especially with operators of limited experience.

**MINIMIZING PINE MORTALITY CAUSED BY PINE ENGRAVERS**

Thinned, vigorous stands generally incur fewer engraver beetle attacks than overstocked stands of young pine, particularly during drought years. Unfortunately, recently-thinned stands may be temporarily more attractive until the increase in tree vigor occurs, and the slash created in thinning may provide suitable material for a rapid increase in engraver populations. There are several approaches to greatly lessen the latter possibility.

Thinning should occur from mid-July to December, with the optimum time being August, September, and October. Slash created from December through the rest of the winter will maintain a fresh quality suitable for a rapid increase in the population that survives. Creation of slash in the spring and into July further enhances the probability of undesirable population increases. However, it is not always possible to avoid creating slash in the high-risk months of December through June. When this occurs, several management practices can be used to help minimize the potential impact.

- Dozer trampling of slash can be effective in reducing the volume of breeding material.

- Chipping is very effective and especially useful in developed areas.

- Slash can be burned, but any heat scorch to surrounding trees will make them more liable to insect attack.

- Lopping and scattering the slash in stand openings will cause the slash to dry sufficiently to prevent completion of the insect life cycle.

- When pine engraver populations increase enough in slash to constitute a threat, the creation nearby of a fresh supply of slash during the flight period of the emerging adults will generally attract the beetles. The slash should be created just as the majority of the population enters the pupal stage. Once this "green chain" is initiated, the technique should be continued for each generation of the season until autumn. The "chain" can then be broken by the slash treatments previously mentioned.

Finally, poorly designed, poorly administered, or careless logging operations can create many problems that lead to excessive killing of residual trees. Avoid future losses by preventing damage to the residual stand. Trees whose roots are exposed or disturbed, or that have large patches of bark knocked off, should be cut and removed at the end of the operation.

## THINNING YOUNG-GROWTH PONDEROSA PINE

The mountain pine beetle is a major pest of young-growth ponderosa pine in Modoc County. Current mortality on the Ft. Bidwell forest is primarily in pole-size timber, but larger and smaller pines are affected also. These trees are usually located where stand density is high for the site. Low tree vigor caused by intensive between-tree (pine-pine, pine-fir) competition underlies the occurrence of mortality.

Several studies have shown that thinning young-growth ponderosa pine stands will increase tree growth and reduce mortality caused by the mountain pine beetle. Removal of competing neighbors may allow residual trees to increase their resistance to beetle attack. Increasing the distance between trees may also reduce the probability that mass aggregations of beetles to one pine will result in adjacent pines being attacked (group kills).

Doubts have been raised about the practical benefits gained by killing beetles and their broods (direct control). Direct control plus silvicultural techniques may give a slightly better control than a silvicultural method alone, but it is doubtful if the results would justify the added costs. Possibly there are occasions when the short-term effectiveness of direct control can be utilized in a stopgap manner to provide time for a thinning program to be implemented.

Two cautions should be considered. Thinning has no application at lower elevations where the pines may already be widely spaced and soil moisture is often critical. Thinning of white fir where fire control has allowed the species to invade drier sites more suited to pine may prove beneficial to firs for short periods. However, these sites should be converted back to pine, because white firs on such sites are subject to frequent outbreaks of fir engravers and various defoliating insects. Secondly, the beneficial effects of thinning may be reduced if the thinned area is small and is surrounded by unmanaged forest in which tree mortality from bark and engraver beetles is frequent and sustained.

## CONCLUSIONS

No single pest is devastating the Ft. Bidwell stands, but several are acting together and separately to reduce growth and kill trees. Pest activity is often a reflection of adverse stand conditions, and at Ft. Bidwell the underlying problem appears to be competition and stress in overstocked aggregates of pine and fir, possibly aggravated by

drought. Any reduction in basal area, combined with the removal of currently diseased or poorly-growing trees, will improve the health of the stands and reduce the losses to insects, fungi, and dwarf mistletoe. Specific management alternatives may include the following:

- Lower the basal area of the densest aggregations.
- Discriminate against damaged or diseased trees, or trees with poor growth or form.
- Remove the overstory fir in dwarf mistletoe-infected stands and thin the advance regeneration to promote sufficient height growth to offset the vertical spread of the parasite.
- Promote mixed pine and fir stands to reduce the threat of disease intensification.
- Minimize logging injury as much as possible.
- Treat green pine slash to minimize the probability of subsequent attacks and mortality by pine engravers.

## REFERENCES

Eaton, C. B. 1941. Influence of the mountain pine beetle on the composition of mixed pole stands of ponderosa pine and white fir. Journal of Forestry 39:710-713.

Wagener, Willis W. 1961. Guidelines for estimating the survival of fire-damaged trees in California. U. S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Misc. Paper No. 60. 11p.

## APPENDIX:

### THE DWARF MISTLETOE RATING SYSTEM

This method is used to estimate the abundance of dwarf mistletoe infections in individual trees. Divide the tree's live crown into thirds horizontally, and rate each third either 0, 1, or 2: 0 = no visible infections; 1 = infections present but less than 1/2 of the branches are infected; 2 = more than 1/2 of the branches are infected. A bole infection counts as a single branch infection.

Add together the ratings for the 3 thirds to obtain a tree rating from 0 to 6. Trees with ratings of 0 are uninfected, 1 and 2 slightly infected, 3 and 4 moderately infected, and 5 and 6 severely infected. Severely infected trees have reduced growth rates, higher mortality rates, and are more susceptible to successful bark beetle attack.